U. S. DEPARTMENT OF AGRICULTURE.

REPORT

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OF

THE ENTOMOLOGIST

FOR

1909.

BY

L. O. HOWARD.

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REPORT OF THE ENTOMOLOGIST.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., August 11, 1909.

Sir: I submit herewith an executive report covering the work of the Bureau of Entomology for the fiscal year ending June 30, 1909, dividing it, in accordance with your instructions, under the following headings:

(1) A summary of the important operations carried on during the fiscal year ending June 30, 1909.

(2) An outline of the plans proposed for work during the fiscal year ending June 30, 1910, under appropriations already made for that year.

(3) Plans of work recommended for year ending June 30, 1911.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

WORK OF THE YEAR.

The work of the year beginning July 1, 1908, and ending June 30, 1909, may be classified, with some modification from the classification of previous years, as follows:

(1) Work on the gipsy moth and the brown-tail moth.
(2) Importations of useful insects.
(3) Exportations of useful insects.
(4) Work on insects injurious to southern field crops.
(5) Investigations of insects damaging forests.
(6) Investigations of insects damaging deciduous fruit trees.
(7) Cereal and forage-plant insect investigations.
(8) Work on insects injurious to vegetable crops.
(9) Work on insects affecting citrus fruits.
(10) Investigations of insects in their direct relation to the health of man and domestic animals.
(11) Work on insects injurious to stored products.
(12) Inspection work.
(13) Work on bee culture.
(14) Unclassified work.

WORK ON THE GIPSY MOTH AND THE BROWN-TAIL MOTH.

Few innovations in the methods of the work on the gipsy moth and the brown-tail moth, as described in previous reports, have been made during the past year, and the work accomplished in preventing the spread of the moths has been quite satisfactory. They have been held within the bounds established a year ago, except in the State of New Hampshire, where a number of localities of occurrence have been discovered to the north of the region formerly known to be infested. It is not likely that a very great spread has occurred during the year, as most of these localities are places hitherto undiscovered but which have been infested for some time.

As in other years, the Bureau has cooperated to a great extent with the state officials of Maine, New Hampshire, Massachusetts, Rhode Island, and Connecticut. As in previous years, governmental activity against the brown-tail moth has been quite limited, since all of the infested States have laws which require property owners to destroy this insect on private lands and requiring the municipalities to take care of the trees along highways.

The fight against the gipsy moth has been carried on continuously throughout the year in conformity with all the best known methods.

WORK IN MASSACHUSETTS.

In Massachusetts, which remains the most seriously infested of all the New England States, the agents of the Bureau have continued cutting underbrush and removing dead wood and undesirable trees to a distance of 100 feet back from the roadway on either side of the roads leading through the worst infested woodlands. Down to the close of the fiscal year about 300 miles have been cleared in this manner, and along the roads where this has been done the foliage was, on July 1, 1909, in nearly perfect condition, making it practically impossible for caterpillars to drop from trees anywhere through this section upon passing vehicles. In a few places the caterpillars on the foliage of trees on cleared roadsides were so numerous, especially on overhanging trees, that many of them were blown, as they hung suspended by silk, into trees which were being cared for, so that an additional strip of about a rod in width was cleared as a precaution to the roadside strips.

In addition to the cutting and pruning necessary, these strips have been sprayed with arsenicals, and much additional territory has also been thoroughly sprayed in localities where it has not been possible to clear roadsides.

Trees in the worst infested localities have been banded with tanglefoot and the caterpillars found below the bands have been destroyed daily. In some of the worst infested places the trees have been examined twice each day, in order that the caterpillars might be killed and thus kept from crawling out into the roads, where they could easily be picked up by vehicles.

Where the caterpillars were not so numerous, trees have been burlapped and the bands turned over when it seemed to be necessary. Occasionally property owners have objected to the amount of cutting needed, but in most cases they have been so well pleased with the result that they have cleared large tracts of underbrush at their own expense. Several towns in Massachusetts are also adopting the methods of the Bureau in caring for roadsides within their limits.

WORK IN NEW HAMPSHIRE.

During the summer of 1908 scouting operations in the woodlands of New Hampshire were continued with a force of 10 men. About November 1, when the leaves began to fall, additional trained scouts were sent into the State, who were among the most expert members of the force in searching for the frequently inconspicuous egg clusters of the gipsy moth. About 100 men were occupied in this way until the eggs began to hatch in May, 1909. This thorough scouting has revealed the presence of the gipsy moth in over 100 towns in the State of New Hampshire.

The infested territory in this State now includes all of eastern New Hampshire south of Lake Winnepesaukee, with a strip 2 or 3 miles deep west of the Merrimac River. The territory south of a line drawn from Dover to Nashua is badly infested, and from the present outlook there does not seem to be much hope of improving conditions under state supervision. In order to hold the gipsy moth in check in New Hampshire, the great bulk of the work must be done by the General Government, at least until additional appropriations can be made by the state legislature.

In addition to the territory found to be infested in all cases at least one town beyond the limits of the area known to be infested has been scouted, as well as territory even beyond these towns where there was any reason to suspect the occurrence of the insect.

The main route of travel for summer tourists up the Pemigewasset valley to the White Mountains, and the route from Ossipee to the mountains, as far as Bethlehem and Bretton Woods, has been gone over very carefully. No indication of the gipsy moth was found north of Ossipee, on the eastern route, nor north of Meredith, on the western route. During this scouting the men destroyed by creosote 371,102 egg clusters, and as each egg cluster contains about 500 eggs a potential army of gipsy moth caterpillars of great size was destroyed. During the summer and autumn a few miles of the roadside cutting, similar to that done in Massachusetts, was carried out.

WORK IN MAINE.

In Maine the state authorities carried the pay roll of the men engaged in the work until their funds became practically exhausted. The state organization was then taken over on the government pay roll, and most of the scouting work was done by the Bureau during the winter of 1908–9, in addition to such summer assistance as it was able to give. Down to the autumn of 1908 efforts in the State of Maine against the gipsy moth have been confined to orchard and roadside work, but during the past winter much woodland work was begun, and several colonies, some of which contained thousands of egg clusters, were carefully cleaned up, the underbrush was cut, trees were pruned, and the infested areas were put in condition for the coming summer campaign. Although more egg clusters were found during the past winter than during the previous year, the infested territory in Maine is now in better condition than it has ever been. The Government is assisting the State in the summer burlap work by carrying a large proportion of the state men on the Bureau pay roll.

The outbreak of the gipsy moth at the soldiers' home, near Augusta, seems to have been overcome, and the outlook for the whole State is encouraging.

WORK IN RHODE ISLAND.

The infested territory in Rhode Island shows continued improvement. During the winter of 1906–7, 80,000 egg clusters were discovered and destroyed. During the winter of 1907–8 only 7,500 could be found, and these were destroyed. During the past winter (1908–9) less than 1,700 egg clusters could be found, which indicates that the insect is rapidly approaching a condition of absolute extermination.

The State has been receiving practically the same assistance as the State of Maine. During the period when the state funds were available the operators were paid by the State, but during the remainder of the year they were carried on the federal pay roll.

During the summer of 1909, 150,000 trees were burlapped, and about fifty of the men caring for these burlapped trees have been carried on the federal pay roll.

During the past winter all of northeastern Rhode Island was carefully scouted, and no additions were found to the previously infested territory. Two towns previously infested have shown no indications whatever of the moth during this scouting, and in another town but one previously known colony continued to show evidences of the existence of the pest.

WORK IN CONNECTICUT.

As in previous years, the State of Connecticut has practically conducted its own campaign. But one large colony was ever known in this State, namely, in the vicinity of Stonington, and aside from sending one of the best federal scouts to that locality for two weeks, the State has not asked for assistance. But six egg clusters were discovered there during the past winter, and down to June 30 only 76 caterpillars were found. There seems to be every hope of the absolute extermination of this colony in the near future.

EXPERIMENTAL WORK.

Although perfectly satisfied that the methods adopted are sound, considerable experimental work has been carried on during the year, with a view of discovering easier and cheaper methods of handling the pest than had theretofore been known. In the course of this work several important discoveries have been made. It has been shown, for example, that pine trees can be protected by a tanglefoot band, even though carrying many egg clusters above the band, since it seems that the young caterpillars do not eat the pine needles, but drop from the trees in search of more tender food until such time as their jaws become sufficiently strong to eat pine leaves.

Experiments with different arsenical mixtures, with different pump pressures, and with different distributing apparatus, as well as experiments in the distribution of dry arsenate of lead upon wet foliage, have been carried out.

An important step in preventing the further spread of the gipsy moth has been taken in cooperation with the different railroad corporations operating within the infested territory. As the result of this cooperation an embargo notice against the shipment of lumber, cord wood, fence posts, railroad ties, and similar forest products went into effect July 1, 1909. The notice issued by the railroads

places upon the shipper the responsibility of requesting inspection when such products are offered for shipment and of presenting a certificate of inspection to the railroads before they will accept the shipments. It is hoped in this way to eliminate such danger as may be threatened through these transportations.

THE BROWN-TAIL MOTH IN NEW YORK.

A small infestation of the brown-tail moth was discovered late in June near Port Chester, N. Y., just across the Connecticut state line. Only a few larvæ were found, and the infested area has been thoroughly burned over and sprayed by the state entomologist, Doctor Felt. No expense has been spared in the attempt to exterminate the insect at this point.

IMPORTATIONS OF USEFUL INSECTS.

As in previous years, the principal efforts of the Bureau in importing useful insects have been devoted to a continuation of the very large scale experiments in introducing from different parts of the world into New England the parasites and predatory enemies of the gipsy moth and brown-tail moth. The parasites have all been received at the gipsy-moth laboratory supported by the State of Massachusetts at Melrose Highlands, Mass., and their care has been assigned, as in previous years, to Mr. W. F. Fiske, of the Bureau.

As explained in the annual reports of the Bureau for the years 1905 and 1906, this work has been distinctly in cooperation with the State of Massachusetts, which has appropriated specific funds for the purpose. In 1905 Congress appropriated the sum of $2,500 for this work, but Massachusetts the same year made a much larger appropriation, and with the consent of the Secretary of Agriculture the Chief of the Bureau of Entomology was placed in charge. During the earlier part of the experiment nearly all of the expense attached to the work was paid by the State of Massachusetts. As the experiment has grown in size, however, it has been found necessary to assign a constantly increasing number of expert assistants from the Bureau of Entomology, until at the present time the General Government is expending in the work about as much as the State of Massachusetts. To the State, however, belongs the credit of having practically instituted the work and for having generously supported it in its full progress.

The writer visited Europe in May and June, 1909, and started forwarding agencies for parasites at Cherbourg, France, and Hamburg, Germany; visited agents and officials in Holland, Germany, Russia, Austria, Hungary, Switzerland, and France; studied the European situation thoroughly, discovered a new and most favorable locality in France, which will be worked to the utmost next summer, and secured largely increased sendings of parasitized material from many points.

Prof. Trevor Kincaid, of the University of Washington, at Seattle, who was sent to Japan during the spring and summer of 1908, and who had, by his successful shipments demonstrated his great ability in this direction, was sent to Russia in April, 1909, in order to secure as many as possible of certain apparently important parasites previously sent over by Russian agents and correspondents. Owing to

various unforeseen conditions, and principally owing to deficient transportation facilities, the material received as the result of his expedition proved to be unsatisfactory on the whole.

Upon Professor Kincaid's own advice it was considered unnecessary to send a second expedition to Japan during the summer of 1909, since the Japanese entomologists had exhibited such a hearty and intelligent interest in the experiment, and the Japanese Government had shown itself so favorably inclined to assist. After a preliminary correspondence between the Secretary of Agriculture of the United States and the minister of agriculture for Japan, Prof. S. I. Kuwana, of the imperial agricultural experiment station at Tokyo, was designated by the Japanese Government to be its official representative in work to be carried on during the spring and summer of 1909. Professor Kuwana has shown himself to be a man of extraordinary intelligence and activity, and a number of interesting and valuable lots of parasitic material have been received from him at the laboratory at Melrose Highlands, Mass. This material was received in uniformly good condition, and this was due to the great care and intelligence shown by Professor Kuwana in its collection and the method of packing and shipping. The hearty thanks of the United States Government are due to the Japanese Government in this matter, and warm individual commendation and thanks are due to Professor Kuwana.

The most perfect service of the present summer was secured in France. Arriving in Paris on the 13th of May, the writer met, by appointment, Mr. René Oberthür, of Rennes, a French entomologist of high standing, and certain of his collaborators. Plans were considered, largely at the suggestion of Mr. Oberthür, which resulted in the institution of a very large scale service, principally in the south of France, and in the employment of a large number of collectors under expert supervision. From this arrangement several thousands of boxes of good material were received at the Melrose Highlands laboratory from this region. In quantity it exceeded the total of all other importations of a similar character made since the inception of the work, and from it have been reared a greater number of important Tachinid parasites than have been reared from all other importations of similar character taken together. Mr. Oberthür has taken up this work voluntarily as a private citizen of France, wholly without compensation, and entirely from his scientific and practical interest in a great piece of experimental work. The warm thanks of the United States, and particularly the New England States, are due to this remarkable man.

Another notable importation of the year consisted of several thousand egg-masses of the gipsy moth received during the winter from Prof. Josef Jablonowsky, director of the entomological station under the ministry of argiculture of Hungary at Buda-Pest. These were collected in various localities in Hungary, and after their arrival in Massachusetts there were reared from them and liberated under the most favorable conditions more than 75,000 egg-parasites of the species known as *Anastatus bifasciatus* Fonsc. This is especially noteworthy, since less than 1,000 of these parasites had previously been received from all localities, the earlier ones having come from southern Russia and from Japan.

In addition to these more or less unusual shipments, quantities of miscellaneous material have been received, for the most part in good condition, as formerly, from numerous collectors in Germany, Austria, Italy, Holland, Belgium, and Switzerland. Eggs, caterpillars, and pupæ of the gipsy moth, hibernating webs, caterpillars, and pupæ of the brown-tail moth, and adult predaceous beetles have been included in these shipments.

In beginning this large experiment in the importation of parasites there were three principal factors to be considered. First, the importation of living and healthy parasites in numbers sufficient to admit of colonization. For the most part this question has been solved, and the work of importation has become a mere matter of routine. The second question was the handling of the parasitic material after its receipt at the laboratory; and the third, what to do with the imported parasites in the field and how to ascertain results. The second problem, namely, how best to handle the parasitic material after its receipt, has also practically been solved. During the earlier years much time and trouble was expended in attempting to devise methods for doing what had never before been attempted upon a very large scale, but at the present time a comparison between the situation and that of four years ago shows that a large bulk of this work, like that of parasite importation, has resolved itself from a tedious and costly experimentation into a matter of routine. Improvements are to be expected and are being discovered. Attempts to secure reproduction of parasites under laboratory conditions have succeeded in a great majority of instances, and in a few wholesale breeding on a large scale has proved economically possible. Pteromalus, which attacks the hibernating caterpillars of the brown-tail, several brown-tail egg parasites, a newly imported egg parasite of the gipsy moth, and *Calosoma sycophanta*, a large predatory ground-beetle, have all been brought under complete laboratory control, and the numbers which it is possible to rear and colonize seem limited only by the expense of the work. The brown-tail egg parasites, however, seem not to be of as great economic importance as supposed.

A newly imported parasite of the gipsy moth eggs was received from Japan in the spring of 1909, for the first time in a healthy condition. Less than a score of these individuals, reared from these imported eggs, have been increased, through careful laboratory management, to more than 2,000, and it is confidently expected that enough will be reared before the close of the present year to allow a test of the efficiency of this parasite in the field.

With the Calosoma beetle the laboratory work during 1907 and 1908 has resulted in the complete laboratory control of the species, and a maximum of reproduction with a minimum of loss has been secured this year. In addition to a number of beetles imported directly from abroad, 6,000 larvæ have been reared in the laboratory and colonized, 100 or 200 in a place. Several other species of predaceous beetles have been imported, and, in some instances, colonized. With one or two possible exceptions, their disinclination or inability to climb into the trees in search of their prey make them of little value in the control of the gipsy moth, although when given the opportunity they will feed upon the larvæ and pupæ freely. Reproduction of several Tachinid parasites of the gipsy moth and brown-tail moth

has also been secured in the laboratory, and work upon the biology of these parasites conducted by Mr. Townsend has resulted in many surprising discoveries which will have an ultimate practical effect.

The problem of colonization of laboratory-bred material and other material and the study of the imported parasites in the field is still open to a great deal of work. The statement made in the last annual report that "it is altogether likely that the species introduced had found conditions favorable to their increase, and that at the present time they exist in considerable numbers," has been strikingly upheld in one instance. A hymenopterous parasite (Monodontomerus), which attacks the pupæ of both the gipsy and brown-tail moths, was first recovered from the field in the early winter of 1908 and 1909, but has since been found fairly evenly distributed over the area of approximately 500 square miles. A similar rapid increase, rendered unnoticeable on account of an equally rapid and very widespread dissemination, can not be expected in every instance, but it is not unreasonable to suppose that it may occur in several.

Recent field work has discovered indications of a considerable spread of Calosoma from the immediate neighborhood of the original colonies, and it seems obviously only a question of a very short time before it will be distributed throughout the entire area covered by the gipsy moth.

Twelve species of introduced parasites and predatory species have been recovered from the field this year, as against six last year, although not all of these have demonstrated their ability to pass an entire year under their new geographical environment.

There have been imported in all, according to present classification, twenty-six species of Hymenopterous parasites. Of these, one or two are probably identical, although recognized under different names as they come from Europe or Japan. At least twelve of these are of very little promise. Some of them have been given thorough tests in the field, and others, on account of their exceeding rarity in connection with the gipsy moth or brown-tail moth, or for other reasons, can not be considered as important. There remain twelve, of which eight have been received in numbers sufficient to admit of the establishment of satisfactorily large and strong colonies. Nearly all of these have been recovered after at least one generation under natural conditions in the open, but not all after a complete year has passed. One more is soon to be liberated. The remaining three have never been received alive in numbers sufficient to admit of satisfactory colonization.

Of the twenty-nine species of Dipterous parasites mentioned in the last report as having been reared from the gipsy moth or brown-tail moth, a certain number may be eliminated for similar reasons. There are about seventeen of varying importance, all but two or three of which are, to all practical purposes, confined to either the gipsy moth or the brown-tail moth. Fifteen, at least, seem to be of economic importance in this connection. All of these have been colonized more or less extensively, and three of them have been recovered from the field.

The close of the present year finds us with twice as many species of introduced parasites available for study in the field as we had last year. Instead of being confined to exceedingly limited areas in the vicinity of the original colonies, several of them are scattered over

extensive areas, and it is hoped by the continuance of the same and improved methods that this number will be increased during the present year. By a more close following of the increase and spread in the field we may be able to more accurately prophesy upon the probabilities as to the time of the reduction in numbers of the pest than we have heretofore been able to do.

OTHER IMPORTATIONS.

In the last report the successful introduction of a European parasite of the imported elm leaf-beetle was announced. Examinations made at points of colonization during the present summer have failed to indicate that the insect successfully passed the winter. It is possible that it may have established itself in localities unvisited this year, but it has not been as successful as was hoped. Attempts to reimport the species this year have failed, owing to its absence in certain European localities and to the untimely death of Prof. Valery Mayet, of Montpellier, France, occurring at the time when he expected to make shipments to the United States. Through the cooperation of Prof. F. Silvestri, of Portici, Italy, unsuccessful efforts have been made to introduce two other natural enemies of the imported elm leaf-beetle.

European codling-moth larvæ were imported from different parts of Europe, especially from Germany, in considerable quantities during the fall and winter, and the work of rearing them was continued at the gipsy-moth parasite laboratory at Melrose Highlands, Mass. The expert in charge of the work found a very scant percentage of parasitism of the material received, though a large percentage of the larvæ succumbed to the attack of a fungous disease.

EXPORTATIONS OF USEFUL INSECTS.

In my last report I called attention to the fact that while the Bureau desires to return the many favors that foreign entomologists have extended to this country by sending them beneficial insects which may possibly be of service to them, this can be done comparatively rarely, but the occasion has arisen several times, and has justified the attempt.

Mention has previously been made of the exportation of certain important parasites of *Diaspis pentagona*, a scale insect attacking the mulberry in southern Europe, which have been sent to Italian officials, and it is a great pleasure to report the apparent success of one of these exportations. Prof. Antonio Berlese, director of the Royal Station of Agricultural Entomology, at Florence, writing under date of July 10, 1909, informs the Bureau that one of these parasites has already spread through the mulberry trees of Vanzago and has entirely relieved them from the destructive scale. The parasite is now being distributed from this district into other similar localities, and it is Professor Berlese's expectation that in two years relief for all Italy will be effected. Further, it has just been learned that through sendings to Prof. F. Silvestri, of Portici, this parasite has been acclimatized at Acerra, Grottamare, and Palombino, Italy.

During the winter of 1908–9 certain ladybird beetles collected in southern California were sent by the Bureau to Malaga, Spain, for

the purpose of preying upon a species of mealy bug. Success has as yet not been reported.

During the summer of 1909 parasites of *Diaspis pentagona* have been sent from Washington to Peru, in an experimental effort to ascertain whether they will successfully parasitize a closely allied scale insect which is greatly damaging the cotton crop in that country.

Other beneficial ladybird beetles have been forwarded by the Bureau to southern Italy, in an effort to acclimatize them as enemies of destructive scale insects.

A new species of tick parasite occurring upon a dog tick in Texas, related to the cattle tick and referred to in a later section of this report, has been sent in considerable numbers to South Africa, in order to ascertain whether it will attack certain congeneric species which are among the most important disease-transmitting ticks in that country.

No further reports have been received as to the success of the exportation of the American sand-digging wasp to Algeria to kill the Tabanid flies which transfer a trypanosome disease of the dromedary, as mentioned in the last annual report of the Bureau. Nor has any further attempt been made during the year to export bumblebees to the Philippine Islands. Dr. P. C. Freer, director of the bureau of science at Manila, states that in April, 1909, descendants of the first importation were found in small numbers in the vicinity of the place where they were liberated in 1908.

WORK ON INSECTS AFFECTING SOUTHERN FIELD CROPS.

The work on insects affecting southern field crops has previously been reported upon in annual reports of the Bureau under different headings and is now, for the sake of convenience, brought together. The whole work has been carried on under the supervision of Mr. W. D. Hunter.

THE MEXICAN COTTON BOLL WEEVIL.

The Mexican cotton boll weevil destroyed at least 400,000 bales of the crop of 1908, of a value of at least $20,000,000. The most noteworthy feature of the situation during the year was the fact that the damage in Texas was light compared to that in Louisiana and in the small portion of the State of Mississippi that had been invaded. Weather conditions in Texas reduced the numbers of the hibernating weevils considerably, but the opportunities for hibernation in the eastern region were so favorable that great numbers survived. Moreover, dry weather during the growing season in Texas retarded the development of the insect, while no such check occurred in Louisiana. Therefore the bulk of the loss fell upon the State of Louisiana. It is perfectly clear that the situation in Texas was abnormal, and that greater damage must be expected whenever the climatic conditions of the winter and spring are more favorable to the weevil. The great loss suffered in Louisiana is a verification of the prediction that has been made by the Bureau of Entomology for several years and indicates the importance of devising means of control adapted to such conditions as are found in Louisiana, Mississippi, and other States that will soon be invaded by the weevil.

Experimental farms.—The general plan of work on the experimental farms that has been followed for several years was continued during the fiscal year. The object of these experimental farms is to apply, under practical field conditions, the results of observations in the laboratory and elsewhere that seem to indicate means of control. New points are being discovered continually. For this reason it is highly desirable to continue the work from year to year. Moreover, in many cases it is necessary to repeat experiments in control through a series of years to determine their relative effectiveness under vicissitudes of different seasons. The experimental-farm work of the Bureau during the fiscal year covered about 300 acres, located at selected points throughout the infested territory.

Utilization of the insect enemies of the boll weevil.—The insect enemies of the boll weevil have come to be of great importance. A large number of examinations were made to determine the mortality rate due to this cause in 1908. It was found in one case that 77 per cent of the boll weevils in a field in Louisiana were being destroyed by their insect enemies. At various points in Texas from 21 to 48 per cent of the weevils were killed in the same way. These records are based on the examinations of many thousands of weevil stages, and indicate the general extent of control brought about by parasites. It is evident that the extent of control secured in this way is much greater than that at the command of the planter by any artificial means. Moreover, it has been found feasible to make certain changes in planting and cultivating systems that will facilitate greatly the work of the enemies of the weevil. Experiments in introduction from one region to another have been made with good success, but it is considered that the most important feature of the parasite situation is to devise means that can be resorted to by the planters to increase their effectiveness. The method of planting, the varieties planted, the spacing of the plants, the methods of cultivation, and the methods of gathering the crop, all have a bearing upon control by parasites. Each one of these features has been investigated and certain recommendations have resulted. The subject is a large and complicated one, dealing with changing conditions, and will require additional work for several years.

In the way of introduction of parasites from one locality into another, encouraging progress has been made. In one experiment the mortality in hanging squares was increased from 9 to 37 per cent by the introduction of parasites from another region. Of course, this experiment was checked by a similar area in which no parasites were introduced. In several cases of this kind parasites that originally did not occur in certain regions were established and in all probability will increase their effectiveness and spread from year to year.

The chain cultivator and other machines for control.—Mention of this device was made in the last annual report. Tests during the season of 1908 demonstrated the effectiveness of the implement. Its use was found to have a practically immediate effect in increasing the death rate of the weevil due to the heat and also indicated great practical value as a cultivator. In fact, it is likely that the use of the implement would be warranted for its cultural effect even if no weevils were destroyed. The implement was examined carefully by

the president of one of the large manufacturing concerns of the country. As a result the company has manufactured a number of machines that have been placed upon the market.

It was discovered during the season that an implement constructed on the principle of the chain cultivator, but with runners of wood instead of chains, might also have an important effect in the control of the weevil. In fact, the wooden implement will probably be found better adapted to some conditions than the chain cultivator.

Special studies in the Mississippi Delta.—For some years the greatest damage by the boll weevil will undoubtedly occur in the States bordering on the Mississippi River. The first season after the original invasion by the weevil in that region has frequently shown a falling off of 50 per cent in the crop. This is much more than the damage done under similar conditions in Texas. The causes for this situation are the precipitation, presence of heavy timber, mild winters, and other features. These all combine to give the boll-weevil problem more serious features than it has had elsewhere. This prediction of special damage was made several years ago by the Bureau of Entomology, and the findings in the delta region during the last year have demonstrated fully that the danger was not overestimated.

One of the most hopeful features in the delta region is a utilization of parasites, but all other means of control must be taken into consideration. For this reason special experiments and observations were made on the life history of the weevil in the Delta. This included experiments in hibernation in the neighborhood of Natchez, Miss. The work in this case was planned primarily to determine what may be accomplished by the destruction of plants at different dates. It is the general impression of planters in the Delta that the destruction of plants will not be as effective as in Texas.

Work on status of weevil.—There is a regular and proper demand for information regarding the status of the weevil and the amount of damage that may be expected. It devolves upon the Bureau of Entomology to furnish this information. To do so requires the examination of many cotton fields at different times during the season, the comparison of the records with those of previous years, and the dissemination of the data thus obtained. This work was continued during the year.

General laboratory work.—In the laboratory of the boll-weevil investigation at Dallas, Tex., many experiments were conducted that were later carried into the field. In fact, whenever anything is discovered in the laboratory in the study of the life history of the weevil or its parasites that furnishes a clew to control, the matter is immediately taken up under practical field conditions. The life history of the weevil is now pretty well understood; therefore the principal work during the season was in connection with the propagation of parasites. In addition, of course, the records of all the experiments outside of the laboratory were kept there, and large numbers of parasites were studied, reared, and disseminated.

Testing proposed remedies.—Many persons continue to offer suggestions about the control of the weevil. These frequently take the form of special preparations, such as poisons. It was necessary, therefore, during the fiscal year to make a number of tests for the

information of interested parties and to guard against the extensive sale of useless substances.

Isolated colonies.—As in other years, a constant effort was made to locate isolated colonies far enough ahead of the general invasion to warrant the undertaking of eradication. This was done through field trips and by correspondence with state authorities and others.

TOBACCO INSECTS.

The work on tobacco insects, begun last year and reported upon in the last annual report, has been continued during the year. The main work was carried on in the dark-tobacco region of Kentucky and Tennessee, with headquarters at Clarksville, Tenn. In this region the damage done by injurious insects to the tobacco crop of 1908 is estimated to have amounted to more than $500,000. The work here was pursued under four main heads: (1) Life history and seasonal studies of the different injurious species; (2) studies of native parasites with a view of increasing their usefulness, and importations of egg parasites of the so-called hornworm from Porto Rico; (3) experiments relating to methods of control; (4) demonstrations of remedies. Under the first heading many important data have been gathered, but the greater time of the investigators has been given to the tobacco hornworms and the flea-beetles, which are the most important pests. It has been found that a spray of arsenate of lead, at the rate of 1 pound of the paste or one-half pound of the powder to 12 gallons of water, is an effective remedy against flea-beetles and also against all other insects attacking tobacco in the plant bed. Paris green at the rate of from 1 to 2 pounds per acre has been found to be effective against the larvæ of the hornworms, but injury to the foliage following this treatment has been reported and experiments with other arsenicals have been undertaken in order to prevent this damage.

Trap cages placed over the flowers of jimson weed were found to capture numbers of moths of the tobacco worm. Fall plowing of land that has been in tobacco during the preceding summer has been shown to destroy 39 per cent of the pupæ of the hornworm that would otherwise hibernate successfully. Cooperative demonstrations of remedies were made at Clarksville, Tenn., and Guthrie and Hopkinsville, Ky.

Additional work was done in Virginia, and during the fall of 1908 a preliminary survey was made at Appomattox, in that State, of damage to tobacco reported to be due to a wireworm. The damage was estimated at $800,000 for the dark-tobacco district of Virginia. It was shown that the injurious insect is a species of Crambus, and an investigation of its life history has been begun.

Although the Bureau had at an earlier date made an investigation of the tobacco thrips in Florida, reports of great damage by planters in Florida brought about a preliminary resurvey during March, 1909. An expert was sent to Florida and visited many growers of shade tobacco at Quincy, and also made collections of thrips to find, if possible, the native food plants and hibernating quarters. From the experiments made it seems possible that the tobacco thrips has a long

hibernating period under ground, like the pear thrips, and if this should prove to be the case the problem of control will be difficult.

During the year, at the request of the tobacco journals, it was decided to make a special investigation of the so-called cigarette beetle. Circular letters of inquiry were sent out during the winter to tobacco manufacturers, and much information was gained. One successful demonstration of carbon bisulphid as a fumigant against this insect was carried on.

OTHER INVESTIGATIONS.

As pointed out in the last report, insects have been found to be an important obstacle to the cultivation of cactus as a farm crop. During the past season it has been found that the damage to the planted cactus has not been overestimated, but that means of control can be put into operation in an economical way. Certain species can readily be trapped in hibernation and burned, and others may be burned upon the plants by the use of torches such as are used in removing the spines, and others may be controlled in other ways. The investigation has practically been completed. Some points require additional study the present season, but it is hoped that the work can be reported upon finally within the next fiscal year.

The necessity for further work upon the insect enemies of sugar cane and rice, as well as upon the so-called Argentine ant, has been forced upon the Bureau, and toward the close of the fiscal year arrangements were made to begin systematic work upon these pests, beginning with the first of July, 1909. These investigations will be outlined later in this report.

INVESTIGATIONS OF INSECTS DAMAGING FORESTS.

The investigations of insects damaging forests, carried on under the direction of Dr. A. D. Hopkins, have been restricted during the past fiscal year more than formerly to the various sections of the country where there seemed to be the greatest need for the work. The more important field investigations of the year have related to the following subjects:

THE WHITE PINE TWIG BLIGHT.

Investigations were carried on in New Hampshire, Maine, and adjoining States, to determine the relation of insects to the several forms of twig blight of the white pine, and incidentally a number of other forest-insect problems peculiar to the New England States were investigated. This has resulted in the determination of some of the causes of the twig blight and the accumulation of many new facts of systematic and economic importance.

INJURIES BY INSECTS TO STORM-FELLED TIMBER.

Investigations were continued in Mississippi and Arkansas on the relation of wood-boring insects to subsequent damage to storm-felled pine timber in the Southern States. This has resulted in the accumulation of evidence to indicate that the storm-felled timber in Mississippi, Louisiana, Alabama, and Arkansas, resulting from the

great storms of 1906, 1907, and 1908, amounted to over 2,000,000,000 feet, board measure, and that during the period in which the timber was sound enough for lumber it was reduced in value 25 per cent by wood-boring insects. It has also been determined that a large percentage of this loss can be prevented, now that the essential details in the habits of the insects are known.

INSECT DEPREDATIONS IN PRIVATE FORESTS.

Investigations were continued in the private forests of northern California during the summer of 1908 and winter of 1909, in which much new and valuable information was accumulated and on which special recommendations to the owners were based, but further progress toward securing the desired practical demonstrations was prevented by unforeseen personal troubles affecting the field agent in charge of the work.

SULPHUR-FUME INJURY AND INSECTS.

A special investigation was made of the relation of injury by sulphur fumes to previous and subsequent injury by barkbeetles to the timber on private and other lands in the vicinity of Anaconda, Mont., resulting in the conclusion that such relations were of little or no economic importance.

PRACTICAL DEMONSTRATION WORK.

Investigations relating to practical control have been continued in the national and private forests of the central Rocky Mountain region. Special attention has been directed to the securing of statistical data and to the concentration of the cooperative efforts of the Bureau of Entomology and the Forest Service on securing the proper application of the recommendations of this Bureau for the control of extensive depredations by the Black Hills beetle, so as to furnish forcible and convincing demonstrations of the practicability of such control. In all of this work marked success has been attained.

INSECT DAMAGE TO HARDWOOD PRODUCTS.

Investigations of the insects damaging hardwood products and practical demonstration work in their control have been continued, principally in direct cooperation with the more extensive operations in the manufacture of handles, agricultural machinery, vehicles, army and navy stores, etc., and most gratifying progress has been made.

COOPERATION.

Forest entomology and forestry.—The cooperation between the Branch of Forest Insect Investigations of this Bureau and the Branch of Silviculture of the Forest Service comprises the investigation of practical methods of insect control and efforts toward securing the proper practical application of available technical and other information on the insects and local forest conditions in the inauguration of policies of insect control in the various National Forests of the country.

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The feature in this cooperation which has yielded most satisfactory results is that in which the Branch of Silviculture furnishes an experienced forest ranger to work under immediate instructions from the forest entomologist in charge of the Branch of Forest Insect Investigations in the location and marking of beetle-infested trees and in securing information on practical and local details to supplement the final recommendations by the forest entomologist for the practical control operations which are conducted by the local forest official under the supervision of the insect-control ranger.

Forest entomology and forest pathology.—While there is no cooperative agreement between the Laboratory of Forest Pathology, of the Bureau of Plant Industry, and the Branch of Forest Insect Investigations, there is a most congenial and helpful interchange of ideas and suggestions, and some cooperative investigations on subjects and problems involving the intimate interrelation of insects and fungi.

Forest entomology and private interests.—A most promising cooperative arrangement for the attainment of immediate practical results from the proper and most economical application of expert information in forest insects and the prevention of losses from their ravages has been effected with certain manufacturers of forest products, in which the company furnishes a thoroughly practical man (who is familiar with the details of manufacturing, handling, storing, and finishing the products that are subject to damage by insects) to work under immediate instructions from the forest entomologist in the conducting of all insect-control and experimental operations that involve, as essential features for their success, a technical knowledge of the insects. In other words, all questions relating to the insects and the essential details on methods of control are decided by the entomologist, and all questions relating to the adjustment of business methods and to local conditions and requirements favorable or otherwise for the practical application of any part or all of the recommendations are decided by the representative of the company. When an agreement is reached all of the expenses of the experiments and practical application in control work are borne by the company.

Cooperation in control demonstrations.—During the latter part of the year certain combinations of circumstances and subsequent information secured through this Bureau led to the activity of a resident of Montana (Mr. Josef Brunner) in calling public attention, through the press, correspondence, and otherwise, to the extensive depredations by barkbeetles in the vicinity of Pine Grove, Mont., and to the need of prompt action under the advice of the Bureau of Entomology. The infestation involved timber on private and state lands, the national forests, and the public domain. This combination of interests, with requests for information and action on the part of the Government, coming from state officials, including both Senators and the Representative, and from a prominent commercial club, presented at once a most interesting and complex situation in which it was plain that nothing whatever could be accomplished without definitely organized effort. Therefore Mr. Brunner was appointed by the Secretary of Agriculture as an agent of this Bureau, to work under our immediate instructions. Mr. Brunner proceeded at once to locate and mark the infested trees and to estimate the cost of the required control operations. He reported that 1,000 infested trees had been

located on private and state lands and 100 on the national forest, and that it would cost approximately 30 cents per tree to cut and bark them to kill the insects. Upon receipt of this report, propositions were made to the Forest Service, state officials, and the commercial club that an agent of this Bureau was ready to proceed with control operations if the required money to cover the actual cost of the operations was provided. The Forest Service promptly appropriated $100 to cut and bark the infested timber on the national forests. After some delay and the loss of precious time, the parties in charge of the state and private interests indicated their willingness to provide the necessary funds, and at the latest practicable date the control work was started with good prospects for its completion in time to destroy the insects before they emerged to extend their depredations in the remaining living timber.

Whether or not this particular effort succeeds and serves its primary object of demonstration, it opens up new and most promising possibilities for further action along similar lines of direct cooperation between this Bureau and national, state, and private interests, either individually or combined, in securing the desired examples of practical and effectual control through the prompt adoption of the proper and inexpensive methods of procedure. Therefore it should be extended to the full limit of the funds and men available for such demonstration control work.

Forest entomology and state forestry.—The last piece of work of the year related to the consideration of plans for cooperation with a state entomologist in a survey of the State, to determine the principal insect enemies of the forest trees and the character and extent of the damage, in which the State furnishes an assistant to work under our immediate instructions, subject to the approval of the state entomologist. The results are to be published by the State, under joint authorship. This seems to open up another field of opportunity and usefulness in survey and practical control work, by which a State, through the expenditure of a comparatively small sum of money, can secure authoritative advice based on extensive investigation of national and interstate problems, and by which at the same time this Bureau will be afforded exceptional opportunities to disseminate information and make practical demonstrations which will contribute to one of the desired ends, viz, a more general recognition of the importance of the subject and the practicability of preventing losses.

PRACTICAL RESULTS.

Control of the Black Hills beetle.—The permanent value of the successful efforts to control the Black Hills beetle in the vicinity of Colorado Springs and on an extensive private estate in southern Colorado, mentioned in the 1908 report, have been verified by observations during the past year, which failed to reveal any evidence of new infestations.

The practicability of controlling this most destructive enemy of the pine timber of the central Rocky Mountain region, not only without ultimate cost but at a profit on the first cost of the operations, has been demonstrated during the past year on a large private estate and the adjoining Pike National Forest, in north-central Colorado. An examination of the timber in the spring of 1907 by

the ranger detailed from the Forest Service to work under our instructions showed that the depredations by the beetles had been going on for the past ten to fifteen years or more, and had resulted in the death of more than 800,000 board feet of the finest timber. About 65,000 board feet of timber was found to be infested by the beetle at the time of the examination. The owner was notified of the dangerous character of the infestation and the required action recommended to control it, but no action was taken. Another examination of the property was made in the fall of 1907, when it was found that the new infestation resulting from swarms of beetles that had been allowed to emerge from the old infested trees involved nearly four times as much timber, or 240,000 board feet. This alarming increase led to the prompt adoption of our recommendations by the owner and the Forest Service, and by May of the following spring (1908) the small number of trees on the national forest were cut and barked, to kill the insects in the inner bark, and the thousand or more trees on the private estate were felled, the logs converted into lumber, and the slabs burned, which accomplished the desired purpose of destroying the broods of the beetle. The owner realized a sufficient revenue from the timber thus involved to cover all expenses and leave a net profit of over $1,200. Examination of the area in the fall of 1908 showed that this prompt and properly conducted effort to control the beetle was a complete success. Thus the average death rate of some 100,000 feet of timber annually during the past ten or more years was reduced to a minimum, at a net profit on the cost of doing it.

The cash value of this result, as based on present and future stumpage value of the living timber thus protected in the private and national forests of the entire area coming under the influence of such control operations, is evidently not less than $50,000, and its value as a demonstration of the absolutely practical and inexpensive method of controlling an extensive invasion of the Black Hills beetle should be worth far more than the cost of forest-insect investigations during the past ten years.

Profiting by the results attained in the control of this beetle in private forests, special efforts have been directed to its control in the Las Animas National Forest and the Wet Mountain section of the San Isabel National Forest, both of which have suffered so severely from its ravages that it is estimated that more than 3,000,000 board feet of merchantable pine has been killed during the past ten years, or an average of about 300,000 feet per year. In addition to infested trees disposed of by the Forest Service in timber sales, 165 infested trees in one section of the Las Animas were cut and barked in May and June, 1908, at a direct cost of $177.50, and at the same time a considerable amount of infested timber was disposed of by sale in the Wet Mountains. This had a decided effect in checking the ravages of the beetle, and it was followed up the next spring (1909) by the proper disposal of over 1,300 infested trees by free use, ranger labor, and direct expenditure of funds appropriated by the Forest Service. Therefore, the thorough and proper manner in which our instructions were carried out in this case will evidently bring the beetle under complete control, effectually protect the remaining living timber, and, what is more important, serve as an example of the necessity and practicability of insect control in the National Forests.

Control of the mountain pine beetle.—It is evident that if the necessary funds are made available and the extra force of men can be secured to fell and bark the thousand or more trees in the vicinity of Pine Grove, Mont., infested with this near relative of the Black Hills beetle, an equally destructive enemy of the pine timber will be brought under complete control, and this will serve as another demonstration of the possibility of attaining the desired control under an exceptional combination of difficulties.

Progress in the control of powder-post beetles.—The direct answer to a series of questions sent to principal correspondents of this Bureau who have requested information during the past six years on methods of preventing losses from powder post show conclusively that in the numerous cases where our recommendations have been properly carried out most gratifying results have been attained, thus demonstrating the value of such recommendations in actual practice.

INVESTIGATIONS OF INSECTS DAMAGING DECIDUOUS FRUIT TREES.

The investigations of the Bureau against the group of insects damaging deciduous fruit trees have been carried on under the direction of Mr. A. L. Quaintance, and have covered a wide field.

THE PEAR THRIPS.

The investigation of the pear thrips, begun July 1, 1907, soon bid fair to prove one of the most important pieces of work carried on by the Bureau. The damage already accomplished was very great, and that threatened was excessive. While the infested territory is at the present time included within a radius of about 100 miles from San Francisco, the character of the damage is great and the spread of the insect is practically certain. The immediate necessity for competent remedies is striking. Full studies of the life history of the insect have been made and large-scale experiments in all directions have been carried out. The possible value of applications of fertilizers and of soil fumigation, irrigation, etc., to bring about the destruction of the insects in the soil has been investigated without important practical results. Experiments in deep plowing of the soil during the summer to destroy the larvæ, which at this period are all beneath the surface of the ground, gave practically negative results, since the larvæ are active at this period and are quickly able to reconstruct new cells, in which they will live undisturbed. In the autumn, however, it was discovered that deep plowing and cross-plowing with harrowing after the first rains are remarkably effective. At this time the insects are mostly in the helpless pupal stage and are very susceptible to any disturbance. In two orchards in the Santa Clara Valley, where this method was thoroughly tried, there were killed, respectively, 70 and 73 per cent of the insects. Moreover, this process, in addition to its great value in destroying the thrips, is very beneficial, since it puts the soil in better condition to retain water from the winter rains and brings about a more vigorous condition of the trees.

In addition to this excellent result, spraying tests in the spring of 1909 resulted in the discovery that a combination of a tobacco extract in the proportion of 1 to 60 of water with 2 per cent of the distillate oil emulsion produces a perfectly satisfactory spray of

excellent penetrating qualities which kills practically all of the thrips which it touches without any injury whatever to the trees.

Extensive experiments were carried on in the Santa Clara Valley and in the Ignacio and San Ramon valleys in Contra Costa County. Through the material cooperation of the authorities in the counties mentioned, and also that of orchardists, it was possible to conduct the work on a much larger scale than would otherwise have been possible.

It seems that the adults of the pear thrips are for the most part out of the ground and congregated upon the trees before the blossoms have opened to any extent, and it was found that one or two thorough applications of the spray mentioned, under high pressure and directed downward to force the liquid into the bud clusters, will destroy a great majority of the insects present. Careful estimates of the results of this work place the percentage of thrips thus killed at from 90 to 97.

The long period between the swelling of the buds and the actual opening of the flowers in California greatly favors the work of spraying. After the petals of the flowers have spread the insects work inside and are protected.

The spraying operations in both counties were uniformly favorable, and resulted in protecting the blossoms and insuring a fruit crop in orchards in which for some years the crop had been destroyed by the thrips. Several orchardists, acting under the instructions of the Bureau's agents, obtained very satisfactory results, and have expressed full confidence in the entire efficiency of sprays and the method of cultivation described as remedies for the thrips. The use of either or, preferably, both methods in conjunction should give a large degree of freedom from further injury.

In September, 1908, the writer visited California and found the fruit growers practically in despair. One large orchardist expressed himself as confident that nothing could be done and was cutting down a large portion of an orchard valued at $250,000. The matter had been called to the attention of the State Board of Trade, and the utmost anxiety was felt over the probable spread of the insect, not only throughout all the fruit-growing regions of California, but to the more northern Pacific States, and ultimately toward the East. As the result of two years' work the Bureau feels that the problem is solved, and it only remains to conduct some additional demonstrations and to carry out a few additional experiments before the problem can safely be left to the orchardists themselves. Much credit should be given to the boards of supervisors of Santa Clara and Contra Costa counties for financial assistance in both experimental and demonstration work, and to individual orchardists for cooperation in the use of their orchards.

CRANBERRY INSECTS.

As pointed out in the last annual report, the methods of control of cranberry insects which were more or less satisfactory in the cranberry bogs of New Jersey and Massachusetts were not effective in the bogs of Wisconsin, and cooperative work between the Bureau of Entomology and the University of Wisconsin had been instituted. This work during the past fiscal year has been continued

and enlarged. Owing to local conditions which render flooding of questionable safety, especially in midsummer, attention has largely been given to sprays. The cranberry fruit worm is at present by far the most serious pest in the State, and destroyed last year about 30 per cent of the crop, while in certain bogs from 50 to 65, and even 95, per cent was destroyed. Effective spraying can be practiced only on bogs reasonably clean of grass and weeds, and it has thus been necessary to give attention to the subject of cultural methods. Large-scale spraying demonstration experiments have been carried out in different portions of the cranberry marshes in the Cranmoor district, and have shown uniformly a considerable benefit. Combination sprays of Bordeaux mixture and arsenate of lead have reduced injury by the fruit worm from 60 to 14 per cent. This would be equivalent to a money gain, based on average yield and price, of $86 an acre. In the spring of 1909 it was planned to do more spraying than last year, in cooperation with cranberry growers, who would provide for a considerable portion of the expense.

THE CODLING MOTH.

Of late much interest has been shown in the one-spray method advocated in the Northwest against the codling moth as applied to the usual schedule of applications followed by eastern orchardists. During the season of 1909 an effort has been made to secure all of the conditions necessary for one-spray work, and tests are being made in Virginia, Michigan, Arkansas, and Missouri to secure data from representative fruit regions as to the effect of variable climatic and other conditions. It is too early as yet to report results.

Extensive experiments were made during the summer of 1908 in the Ozarks, in cooperation with the Missouri State Fruit Experiment Station and the Bureau of Plant Industry of this Department, to determine the relative merits, in the control of insects and fungous diseases of the apple, of liquid and dust sprays. The dust sprays are much in use in the Middle West, although a great difference of opinion prevails as to their value. The result of the summer's work indicated a great superiority in liquid sprays, although some points investigated need confirmation, which is being obtained during the summer of 1909.

Demonstration spraying for the codling moth and apple diseases has been carried on in cooperation with the Bureau of Plant Industry in orchards in Arkansas, Virginia, Michigan, and western Missouri. The demonstration spraying in progress last season in southeastern Nebraska was successfully concluded, exact records being kept of the cost of the operations and the benefit in money as a result. A net gain of spraying of from $2 to $5 per tree resulted, and this is considered to be very favorable.

Further observations have been carried on in relation to the work of the codling moth in pears. Since the calyx lobes of pears do not close as they do with apples, certain differences in treatment are necessary, and spraying experiments have been carried on, at the request and in cooperation with pear growers in California, to determine the practical effect of these differences, and agents are also at the same time making life-history observations as possibly showing the necessity for differences in treatment.

THE GRAPE ROOT-WORM.

The work on the grape root-worm, begun in the spring of 1907, has been continued in the Erie grape belt, with headquarters at North East, Pa., in cooperation with the state department of agriculture of Pennsylvania. It has been shown to be practicable to protect young vineyards from further injury by a system of spraying and cultivation and also by the schedule of treatment which includes pruning, cultivation, spraying, and the use of fertilizers, to restore to excellent bearing condition old vineyards so badly injured by the root-worm as to become unprofitable.

ARSENIC ACCUMULATION IN SOILS IN SPRAYED WOODLANDS, ORCHARDS, AND VINEYARDS

The dying of orchard trees in certain portions of Colorado has recently been stated to result from the accumulation in the soil of arsenic following spraying, the arsenic becoming soluble and injurious to the trees by reason of alkali present in the water. The danger of similar injury under eastern conditions has, in consequence, been more or less agitated, especially in connection with the use of excessive strengths of arsenate of lead in the control of the brown-tail and gipsy moths. The question of danger of injury to orchard trees has also been raised. The importance of the matter warranted an immediate investigation, which has been undertaken in cooperation with the Bureau of Chemistry. Soil samples have been obtained and referred to the Bureau of Chemistry from woodlands in the vicinity of Boston, and from orchards in western New York, Illinois, Arkansas, and Virginia, and from vineyards in Erie County, Pa.

INSECTICIDE INVESTIGATIONS.

The increasing use of self-boiled lime-sulphur wash as a fungicide in place of Bordeaux mixture, especially on apple, has called for information as to the safety to foliage and efficiency of arsenicals when added to this preparation to effect a combination treatment for insects and diseases, as has been done for many years in the case of arsenicals and Bordeaux mixture. In cooperation with the Bureau of Plant Industry, numerous experiments have been made by adding to the self-boiled and commercial sulphur washes both arsenate of lead and Paris green in the usual quantities for orchard work. The tests made and in progress during the season of 1909 indicate that arsenate of lead may be safely used in the self-boiled wash on apple, and that it is not more injurious to peach foliage or fruit than when applied alone. While important chemical changes undoubtedly take place upon the addition of the arsenate of lead to the wash, as shown by a decided change in color, no injurious by-products apparently are formed. In the case of commercial sulphur solutions some injury has been noted. Also injury to foliage has resulted where Paris green was employed, though perhaps not more so than when this arsenical was used alone. In the course of these tests the self-boiled wash has been found to be very destructive to plant-lice infesting the apple and other plants, and equal in effectiveness to other insecticides commonly used against this class of insects. The tests with self-boiled lime-sulphur wash as a summer treatment for

the San Jose scale mentioned in my last report showed that even very badly infested trees could be largely freed from the insects by the two or three necessary sprayings employed in controlling fungous diseases. It therefore seems probable that, in addition to being an excellent and safe fungicide, as has been shown by the Bureau of Plant Industry, when so used on trees in foliage it will at the same time control scale insects and plant-lice, and by the addition of arsenate of lead will also act to control fruit and leaf feeding insects. The range of usefulness of this wash as a fungicide and insecticide clearly indicates that it will at once come into extended use.

FRUIT-TREE BARKBEETLES.

The investigation of fruit-tree barkbeetles in cooperation with the Ohio Agricultural Experiment Station, with headquarters at Lakeside, Ohio, was continued to the close of the growing season of 1908, and a preliminary report (Part IX of Bul. 68) was issued. The authorities of the Ohio Agricultural Experiment Station, while desirous of continuing the cooperative agreement for the season of 1910, were at the same time in position to carry out the work unaided by the Bureau, and consequently this work was closed, so far as the Bureau is concerned.

CEREAL AND FORAGE-PLANT INSECT INVESTIGATIONS.

As during the last year, the work of the section of cereal and forage-plant insect investigations of the Bureau, in charge of Mr. F. M. Webster, has been devoted largely to the so-called "green bug," the jointworms, and the Hessian fly, but new subjects demanding investigation have arisen, and the past fiscal year has been one of hard work and good results.

THE SO-CALLED "GREEN BUG" AND ITS PARASITES.

The so-called "green bug" was so greatly reduced in numbers by its natural enemies in 1907 that it was practically absent from most of its range until the late summer and early autumn of 1908. Its native food plants have been studied and twenty-five species have been found, on many of which it can feed as on grain, these constituting alternative food plants. The life history of the species has been followed continuously through two years, and the conditions have been ascertained which facilitate its increase with the greatest rapidity. A number of new parasites have been found and the habits of the principal species have been studied with great care, and the knowledge has been gained of just when and under what conditions these parasites can be depended upon to prevent an invasion of the green bug and what the farmer must do himself to ward off or reduce the severity of the invasion. The temperature of the winter of 1908–9 was favorable for the development of the pest, and the abnormally low temperature in the spring of 1909 gave the insect a chance to increase in numbers, so that during the late spring there were local injuries in western North Carolina, northern Georgia, southern Oklahoma, and southeastern New Mexico. The investigations of these local outbreaks have shown that the farmer can do much to protect himself by preventing the growth of volunteer grain in fields

intended for fall wheat or oats and by delaying the sowing of these crops as late in fall as possible. The object is to prevent the pest from becoming established in the fields until a late date in the fall. This reduces the period during which the growing grain may be attacked and prevents the increase of the green bug to the destructive point before its natural enemies arrest it in the spring. Should the pest, however, become established in the field early in the autumn its work will first be observed in spots, and these spots can be treated effectually by kerosene emulsion or by the whale-oil soap mixture, or they can be plowed under and the surface of the ground rolled, or straw can be scattered over the spots and burned.

It seems unlikely that the farmer himself will be able to determine whether his crop is threatened. The insect is so minute, so secluded in its habits, and resembles other plant-lice so much that it requires competent entomologists to constantly watch the status. This should be done by employees of the Bureau and of the different States involved, in cooperation.

WORK ON JOINTWORMS.

Careful studies in the Northwest of damage by the wheat strawworm have indicated that damage from its ravages can be prevented by cultural methods. Its injury is induced by growing crops of winter wheat repeatedly upon the same land; by leaving volunteer plants among the spring wheat; by allowing the summer fallow to grow foul with volunteer wheat, even at a distance from wheat fields, and by growing spring wheat near winter wheat. The remedy lies in avoiding these conditions by rotation of crops, clean early summer fallow, and the abandonment of spring-wheat culture in infested regions.

A serious outbreak of the true joint-worm in Ohio, Indiana, and Illinois has occurred. Information is accumulating which goes to show that late seeding of wheat in connection with rotation of crops tends to reduce its injuries.

HESSIAN FLY INVESTIGATIONS.

In 1908 there was an outbreak of the Hessian fly in southern Kansas, which was so severe that many fields were left unharvested. Fortunately, three series of wheat-sowing experiments had been established by the Bureau in the fall of 1907 in Kansas, and two of these were within the area of severest destruction by the fly in 1908. In this way the Bureau had exact data to work upon both preceding and during the outbreak. The immunity of wheat sown after certain dates in the fall of 1907 was so apparent that a campaign of late sowing, based on these results, was instituted and followed up by the experiment station, the agricultural press, the millers, the grain dealers, and, in one instance, by a church organization. As a result the crop of 1909 practically escaped attack, the parasites, and particularly the species introduced by the Bureau from Pennsylvania, having apparently overcome the pest in those instances where its numbers were increased by volunteer and early sown wheat. At the prevailing price of wheat during 1908 and 1909 it is a safe estimate that the wheat-sowing experiments in Kansas resulted in the saving of $500,000 or more. The investigations on this insect will be continued, and will include work in transporting parasites and establishing them on the Pacific Coast and elsewhere.

OTHER INVESTIGATIONS.

The slender seed-corn ground-beetle has been studied for two years. Under-drainage, rotation of crops, and late planting have been found to afford almost perfect control of the pest.

The investigations on the southern corn root-worm have been continued with gratifying results, and practical preventive measures seem to be in sight.

The southern corn leaf-beetle is being studied by an agent, and careful investigations are being made of the sorghum seed midge, since planters of the South are unable to grow sorghum seed on account of the ravages of this insect.

A most unusual and serious state of affairs has been found to exist in northeastern New Mexico, where the larva of a large moth of the genus Hemileuca has been attacking the grama grass on the cattle ranges in increasing numbers and over continually widening areas. Hundreds of acres were ravaged last year, leaving the ground as bare as if it had been burned over. In October and early November the moths swarmed over the country miles from their place of origin and deposited their eggs in millions. The pest bids fair to render many square miles of range absolutely worthless for grazing. These insects are being carefully investigated by the Bureau.

Other insects now being studied are the corn root-aphis, the cowpea curculio, a new wheat enemy in New Mexico of the genus Meromyza, alfalfa insects, a corn leaf-miner, clover insects on the Pacific Coast, grasshopper outbreaks and their control, and other outbreaks.

WORK ON INSECTS INJURIOUS TO VEGETABLE CROPS.

The widened scope of work on insects injurious to vegetable crops, under the direction of Dr. F. H. Chittenden, has made possible more satisfactory results than heretofore. The reasons for the establishment of stations to study these insects were given in the last annual report.

INVESTIGATIONS IN TIDEWATER VIRGINIA.

The Bureau was continuously at work in 1908 in cooperation with the Virginia Truck Experiment Station and a produce company of Norfolk, Va., upon the insects damaging the truck crops of that region, the total value of which is estimated to amount to $15,000,000. The principal insects studied were spinach and cabbage plant-lice, the Colorado potato beetle, the striped cucumber beetle, the onion thrips, the bean leaf-beetle, the pea aphis, the cabbage webworm, and some others. Field work on a large scale with different remedies was carried out, and it was demonstrated that with the majority of these species control is easy and economical.

WORK IN SOUTHERN TEXAS.

The same class of work has been carried on in southern Texas as in previous years. The insects under special investigation have been the melon aphis, the onion thrips, some beetles closely related to the northern cucumber beetles, corn root-worms, certain forms of beetles

injurious to potato, several flea-beetles, including a new enemy of beets, the southern cabbage butterfly, and certain species of leaf-hoppers, and a number of injurious caterpillars, including the imported cabbage webworm. Extensive work has been done on a number of these species, many of which have not been previously investigated.

The insect enemies and parasites of a number of species of plant-lice have been studied, and there is some promise of interchange of species of beneficial parasitic and predaceous insects to act as destroyers of the melon aphis.

WORK IN FLORIDA.

The principal subject of investigation in Florida has been the tomato fruit-worm, or corn earworm, with especial reference to its control on tomato. It was ascertained that the most successful means of fighting injury by this insect is to plant early and also to make several successive plantings of corn in the tomato fields, so that in the last five weeks of the growing season there will be a supply of corn silk to attract the moths to lay their eggs. This draws them from the tomato and is a practical point of some importance.

The pickle and melon worms were also studied, and work on their life histories was completed. For the melon worm, arsenate of lead has been found to be the best method of control. This is sprayed upon the foliage for the earlier generations, and is not dangerous to melon eaters.

OTHER WORK.

Further investigations have been made in the principal sugar-beet regions in southern California, where two species of plant-lice affecting the beet roots, the beet leaf-miner, certain flea-beetles, and other insects are doing considerable damage.

In addition to these distinct pieces of work, a general survey of truck-crop insects the country over has been kept up, and studies have been made of numbers of the most important species.

An interesting development of the year has been the finding of a parasite of the eggs of asparagus beetles in New England. This parasite on one farm developed to such an extent as to render the employment of artificial remedies unnecessary, resulting in the saving to this farm of about $200, which would otherwise have been expended in insecticides and labor. This parasite is under investigation by the Massachusetts experiment station and by the Bureau with a view to its possible introduction into other localities.

WORK ON INSECTS AFFECTING CITRUS FRUITS.

Work on insects affecting citrus fruits has been carried on during the year under the direct supervision of Mr. C. L. Marlatt. The principal items have been a continuance of the white-fly investigations, work on the hydrocyanic-acid gas fumigation in California, and work upon the orange thrips, also in California.

WORK ON THE WHITE FLY.

The investigation of the white fly in Florida has been continued with the view of placing every practicable line of control on the best possible basis. The decrease in profits from citrus culture in Florida during the last two years has emphasized the necessity for a most exhaustive study of all phases of the subject, so that advantage may be taken of every factor which may aid in reducing the expense of control to a minimum. During the fiscal year ending June 30, 1909, life-history studies and fumigation experiments were practically concluded, experiments with contact insecticides were taken up again after having been discontinued temporarily to allow the conclusion of the more important fumigation experiments, experiments with the fungous parasites were continued with much progress in determining their degree of usefulness, and the study of trap foods has been taken up as a new project.

It proved desirable to carry certain lines of life-history studies of the citrus white fly through another year in order to cover a wider range of conditions. The discovery of the existence of another injurious species of white fly on citrus trees in Florida has made necessary a comparative study of its life history, economic importance, and control. Fortunately, this second species is of limited distribution, has no other known food plants than citrus, and is more easily controlled. It has been found that where it occurs in the same tangerine or orange grove with the citrus white fly (*Aleyrodes citri* R. & H.) it assumes a position of relative insignificance.

Fumigation experiments were conducted on a large scale in cooperation with several orange growers. The main object has been to determine to what extent this process may be used, without regard to the white-fly situation in neighboring groves, by citrus growers whose groves are not isolated. In addition, extensive experiments have been conducted in fumigating nursery trees, which will be of great value to nurserymen and to orange growers with newly planted groves. The new process of estimating the dosage referred to in the last report has been used by previously inexperienced citrus growers with success, as was predicted. This process, consisting of a specially marked tent for use in connection with a new form of dosage table adaptable for use against any insect, has been introduced into California and made the basis of an improvement in the old system of fumigation in that State.

An extensive series of experiments has been conducted to determine the efficiency, cost, and the effect on citrus foliage of each of the many contact insecticides in use against the white fly. The time required for work in progress in other lines did not permit the completion of all spraying experiments as planned. There remains for completion a thorough study of the methods of application. The type of spray nozzle, its discharge capacity, pressure required for best results, and amount of spray per tree are the important points in this connection.

The experiments with the fungous parasites have resulted in acquiring very extensive data which appear to lead to the conclusion that has been arrived at in connection with fungous diseases of the chinch bug, i. e., that the successful development and spread of the fungous growths are too dependent upon weather conditions for

reliance to be placed upon them, even with the best methods of artificial dissemination of the spores. There is a great deal of misinformation current among Florida citrus growers in regard to the efficacy of the fungous parasites, requiring conclusions in this line to be supported by data of the most convincing kind. One species of fungus which has been considered by other investigators as a parasite of the white fly has been proved to be principally saprophytic, rarely, if ever, developing on living insects. It is expected that final conclusions in regard to the known species of fungous parasites of the white fly will be reached by the end of the calendar year.

The investigation of the usefulness of trap foods includes practical field experiments in the pruning of citrus water-shoots at advantageous times and studies of the attractiveness to adult citrus white flies of various non fruit-producing food plants. The pruning of water-shoots has been found to be a very important factor in the control of *Aleyrodes nubifera* under some conditions, and the work now in progress aims to show the limits of its usefulness. The citrus white fly, on the other hand, is not so greatly affected by the removal of water-shoots, but its attraction to china and umbrella trees, as compared with citrus trees, during the time of flight of the first two broods, is such that the possibility of utilizing these trees as trap foods requires investigation. Preliminary studies in this line have been made, but extensive field experiments can not be undertaken before the spring of 1910.

The agent in field charge has been of practical service to many citrus growers from all sections of the State who have visited the laboratory at Orlando for advice and to many others who have asked for advice through correspondence. In this way much has been accomplished in furthering cooperative control measures against the white fly, particularly in sections newly infested.

INVESTIGATION OF HYDROCYANIC-ACID GAS FUMIGATION IN CALIFORNIA.

The work on hydrocyanic-acid gas fumigation in California, taken up at the beginning of the fiscal year ending June 30, 1908, was reported upon in a preliminary way in the last annual report, and the reasons for the investigation were there given. The work has continued along strictly economic lines, with the primary object of increasing the efficiency of fumigation, as well as decreasing its cost. The progress has been satisfactory. A large amount of new and useful information has been secured which, put into practice with the improved methods, has already practically revolutionized the old wasteful procedure which possessed none of the elements of uniformity. Much of this information has been incorporated in Bulletin 79 of the Bureau.

An important system of fumigation, which is both practical and scientific, has been introduced, and is rapidly leading toward a standardization of the entire practice. Within three months after its announcement to the public more than a dozen practical outfits had adopted the methods, while at present it would seem to be a fair estimate that before the next season closes practically all of the fumigating outfits in southern California will be working under the standard system devised by the Bureau. Results from the use of this system on several hundreds of acres of citrus groves have demonstrated a striking superiority over those gained previously, while it seems

quite probable that after the general adoption of the system a single treatment every second year will accomplish the same results as an annual treatment, giving an annual saving of from 30 to 50 per cent of the present cost.

By the experimental treatment of several thousand trees under varying conditions the most economical dosage to be used against the purple scale and the red scale, the most injurious of the enemies of citrus trees in California, has been determined. These experiments have also covered the effects on the results secured of different periods of exposure of the insects to the gas. Exposure of one hour appears to be most effective against the purple scale, while for the red scale the time may be reduced to forty-five minutes.

A number of small practical points have been brought out, including the devising of a new cover for vessels which prevents the burning of tents and allows for the better distribution of the gas. The material used for making the tents has also been looked into, and a number of cloths very superior to those in present use have been found.

In important practical results the investigation has been one of the most satisfactory carried on by the Bureau of late.

THE ORANGE THRIPS.

A new insect enemy of the orange has become prominent in the San Joaquin groves of California, the groves of Portersville and Lindsay, and adjacent territory in Tulare County. This is an important and rapidly developing orange district, and extends along the western border of the Sierra foothills from a point east of Fresno to a point south of Portersville. The orange thrips has been present for some years, but recently its injuries have become so extensive as to attract general attention. It punctures the rind of the newly set fruit and of the older fruit, bringing about the scabby or russet condition and reducing the market value of the fruit. The tender foliage is also seriously injured, especially the foliage of nursery stock.

The investigation of this insect, although it affects citrus fruits, was assigned to the section of deciduous fruit insects, on account of its relationship to the pear thrips under investigation in the same State. A special agent was assigned to the problem in April, 1909, and is giving special attention to methods of control as based upon experience with the pear thrips, and at the same time is carrying on a detailed study of the life history and habits of the insect.

A combination of tobacco extract and distillate oil spray, which proved so effective with the pear thrips, will also kill the orange thrips, but it seems evident that a considerable number of applications will be necessary to protect the orange crop, on account of the continued breeding of the pest, which obviously has several generations and no long resting period, in contrast to the pear thrips.

INVESTIGATIONS OF INSECTS IN THEIR DIRECT RELATION TO THE HEALTH OF MAN AND DOMESTIC ANIMALS.

In the course of the investigations of insects in their direct relation to the health of man and domestic animals, mosquitoes have been actively studied as during the past decade, and new points of practical value have been brought out. It has been discovered that a

large part of the mosquito supply of otherwise well-conditioned sections of large cities is sewer bred, and that the malaria-bearing mosquitoes in dry summers will breed in sewer traps, making it extremely important for the health officials to treat all sewer traps with kerosene or some other culicide.

WORK ON THE HOUSE FLY.

The work on the house fly has been continued, and a bulletin upon this insect and other disease-bearing insects has been published which has attracted still further attention to this unnecessarily dangerous pest. The crusade against the house fly indicated in the last annual report has become, during the past fiscal year, of almost a national character. So many boards of health have taken it up and so many civic organizations have concentrated upon this subject that the whole country may fairly be said to have been aroused. The writer has suggested in a recent publication that an effort be made to change the popular name of the house fly to the typhoid fly, with the idea that should people at large begin to think of it as a disease bearer they would no longer suffer its presence in the house and on their food with the same equanimity as in the past.

WORK ON THE TEXAS CATTLE TICK.

Substantial progress was made in the experimental work on the tick (*Margaropus annulatus* Say) which transmits splenetic fever of cattle. This work was conducted by Mr. W. D. Hunter and Mr. F. C. Bishopp. The observations on the habits and life history were in general in continuation of the work that was under way during the preceding fiscal year. Special attention was devoted to the determination of the points in life history that are of importance in the various systems of control involving the transference of the cattle from one pasture to another. This work is of great importance to ranchmen in the area that can not naturally be reached for some time in the plan of total eradication that is being sucessfully conducted by the Bureau of Animal Industry. Recent agitation has called the attention of cattle owners everywhere to the importance of reducing the number of ticks where the plan of total eradication can not be applied at this time. This has caused a demand for information that the Bureau's work supplies.

Considerable attention was paid to obtaining data regarding the developmental periods of the fever tick in different localities. Work done in one place will not necessarily apply elsewhere. For this reason cooperative experiments were conducted with the Tennessee and Arkansas stations and two experimental localities were utilized in Texas.

In addition to the foregoing work, which is the basis of any control measures that can be put into operation, the Bureau of Entomology conducted several practical demonstrations of the methods of reducing injury. The demonstration in Victoria County, in which an area of a square mile was used for the purpose of cleaning cattle of ticks, was repeated. Another experiment was carried on on a pasture in Calhoun County. In addition to this work, which has been done under formal agreements with the Bureau of Entomology,

a number of ranchmen have taken up the work. Mr. J. D. Mitchell, of the Bureau, has assisted ranchmen in instituting work of this kind in connection with his experimental work.

Tests were made of the possibility of the carriage of fever ticks by animals other than cattle, horses, and sheep. It is highly important to know to what extent other animals may carry the fever species because the occurrence of a comparatively small number of ticks on some other host would nullify all of the work in eradication. It is therefore necessary to obtain very full information. Exceptional cases of various animals serving as hosts must be investigated with care.

In connection with the main work of the Bureau on the various species, attention has been directed to other forms that occur in the South. Several of these, like the lone star tick (*Amblyomma americanum* L.), and the Gulf coast tick (*Amblyomma maculatum* Koch) are of considerable importance as parasites. Man, as well as many domestic animals, is affected by them. Moreover, some of them may eventually be found to be concerned in the transmission of diseases. For these reasons, as time permitted, studies of life histories and habits were conducted.

Some attention was devoted to the study of the fowl tick (*Argas miniatus* Koch) in Texas. In several parts of the world this tick has been found to be the agent in the dissemination of a very serious disease of fowls. In Texas this disease has not been found to occur, but the tick causes very serious injury merely as a parasite. In certain districts the profitable raising of poultry has been rendered impossible. An investigation of this tick has indicated feasible means of control that should enable farmers to reestablish the poultry industry where, in some cases, it has been abandoned.

There is another species, the spinose ear tick (*Ornithodoros megnini* Dugès), which is of importance in the western portion of Texas. This species lodges itself in the ears of cattle and horses and not infrequently causes death, especially in the cases of young animals. While no special experiments could be conducted, observations regarding the extent of damage and the possible means of control were made in connection with the other work. This tick is of sufficient importance to justify special investigation.

A parasite of a tick (*Rhipicephalus texanus* Banks) closely related to the fever-transmitting species was found in southwestern Texas. Experiments were instituted to cause this parasite to attack the cattle tick, but up to this time without success. The parasite is very common in the region of Corpus Christi, Tex., and has an important effect in checking its host, which occurs on the dog. The attempt to cause the species to attack the cattle tick is of especial interest.

A limited amount of work was done on the tick which transmits the so-called spotted fever of human beings.

WORK ON INSECTS INJURIOUS TO STORED PRODUCTS.

Work on insects injurious to stored products, under the direction of Dr. F. H. Chittenden, has been carried on in the directions indicated in the last report.

In continuation of the investigations begun in 1908 at the request of many milling companies in Kansas, Oklahoma, Missouri, and

Texas, and of steamship owners and operators in Texas and Louisiana, much work has been done. Especial attention has been given to the flour beetles and to the determination of the place or places at which export flour from the different States mentioned becomes infested, whether chiefly at the mills or at Galveston, or at New Orleans, or on the cars, steamships, or wagons used in carting the material from the mills to the carrier. There is no doubt that infestation occurs at all of these points, but it is feared that in some cases primary infestation begins at the milling establishments, although some of the mills which have been investigated are kept scrupulously neat and are thoroughly fumigated at least twice yearly.

The insect which has recently engaged the most attention is the Mediterranean flour moth, which seems to be the most destructive mill pest in the world. It was first recognized in this country in 1892, and has since been reported from almost every important milling section of the United States. Investigations by the Bureau seem to indicate that fumigation of milling establishments with hydrocyanic-acid gas is the most perfect method. Bisulphid of carbon is less effective as a rule, and the same may be said of fumigation with sulphur dioxid. It seems possible to stamp this species out with the cooperation of all the milling establishments concerned in any given locality. Experiments indicate that the insects can be destroyed in a badly infested building with two fumigations at the rate of 8 ounces of cyanide of potassium to 1,000 cubic feet of space, provided the buildings have been tightly closed. The economic importance of this pest is indicated by the fact that one miller has stated it has cost him $5,000; another one that it costs $2,000 per year for fumigation.

Several stored-product insects have attracted much attention during the year. These are the granary and rice weevils, the Angoumois grain moth, and the flour beetles. Some new habits of these insects have been discovered, and the experiences of practical grain dealers and millers are being collected, with a view to the publication of a full report on insects affecting stored cereals.

INSPECTION WORK.

As in previous years, the plant material introduced by the Bureau of Plant Industry has been inspected at the Department greenhouses for dangerous insect pests and has been fumigated wherever necessary. Special attention during the past year has been paid to the fumigation of all mango stock on account of the presence of two new Indian scale insects. During the course of the year 1,710 certificates of inspection were granted. Since the regulation of the express companies requires a certificate of inspection to accompany any plant material for shipment, and since there is no official nursery inspector for the District of Columbia, this general inspection work has fallen upon this Bureau. One hundred and four certificates were granted for trees and plants shipped from the District of Columbia, and 2,495 lots of plants imported by the Division of Seed and Plant Introduction of the Bureau of Plant Industry have been inspected for insect pests. Besides numerous cosmopolitan pests, several apparently new species of insects were found and killed.

INSPECTION OF TEA FARM.

During March, 1909, Doctor Shepard, the owner of the tea farm at Summerville, S. C., sent specimens of tea leaves infested with scale insects which were threatening to destroy the plantation. An expert was sent to the farm and found five dangerous scale insects of Asiatic origin infesting the tea plants and neighboring camellias. Since all the tea plants were grown from seed, the method of introduction of these scales was unknown until it was found that large numbers of Japanese camellias had been introduced and planted near the tea plants.

INSPECTION FOR BROWN-TAIL MOTH.

In January, 1909, the Bureau was advised by the commissioner of agriculture of the State of New York that the brown-tail moth had been found in shipments of seedlings from Angers, France. Later advices from Ohio indicated that the winter nests of the brown-tail moth had been found upon seedlings imported from the same locality. Warning letters were sent to different state entomologists; the customs officers at the different ports of entry were notified by the Secretary of the Treasury to inform the U. S. Department of Agriculture immediately upon the arrival of any nursery stock from abroad; the principal railroads were notified of the danger of carrying such plants, and their attention was called to the law of March 3, 1905, providing that no transportation company shall knowingly carry plants infested by injurious insects, under a penalty of a fine of not more than $5,000, or imprisonment at hard labor for more than five years, or both. As a result, not only customs officers but the railroads promptly notified the Bureau at Washington of the ultimate addresses of all cases of plants received, and in this way the Bureau was enabled to notify state inspectors and other competent persons near the points of ultimate destination of such packages, and inspection was thus brought about in all probability in all instances where plants were received after January, and probably also before that date, since information was received from the customs officers of the destinations of the early winter and late autumn receipts. The Bureau was in this way enabled to send notifications of nearly 800 shipments, divided among 35 different States. In fifteen of these States, namely, Alabama, Georgia, Illinois, Iowa, Kansas, Kentucky, Maryland, Massachusetts, Missouri, Nebraska, New Jersey, New York, North Carolina, Ohio, and Pennsylvania, nests of the brown-tail moth were found, and in one locality in Ohio a single broken egg-mass of the gipsy moth was found. Prof. P. J. Parrott, of the New York State Agricultural Experiment Station at Geneva, N. Y., has found in his summer's inspection that still another European fruit-tree pest (*Hyponomeuta padella*) has been introduced, probably on these French seedlings.

NECESSITY FOR A NATIONAL QUARANTINE AND INSPECTION LAW.

This concerted effort to destroy all these imported insect pests was probably successful, but the danger of such shipments was emphasized in a more striking manner than ever before. The United States is practically the only one of the great nations of the world

which has not protected itself from such accidental importations of pests of this character by a national quarantine and inspection law. Such laws have been introduced before Congress in previous years, but have failed of passage. Toward the close of the last session of Congress a national quarantine and inspection bill was drafted and sent to Congress by the Secretary of Agriculture. It passed the House of Representatives, but failed to pass the Senate. The bill as introduced was not satisfactory to the legislative committee of the American Nurserymen's Association, but it is hoped that a measure more satisfactory to them may be introduced at a later date and that the whole country will receive protection through its operations.

In June, 1909, the Chief of the Bureau visited Holland, France, and England for the purpose of looking into the European methods of growing nursery stock for the American market and of investigating the nursery-inspection systems in those countries, which are the greatest exporters to America. He found that the inspection system of the Government of Holland under the direction of Prof. J. Ritsema Bos, director of the pathological station of Wageningen, is admirable. All of the Dutch nurseries are carefully inspected twice each year. The nurserymen are well educated on the subject of remedies. The Ritsema Bos inspection certificate can be relied upon.

In France it was found that there is no governmental inspection system of nurseries. The certificates attached to shipments of nursery stock received in this country coming from France are signed, as a rule, by men connected with the agricultural schools, and, as last winter's experience has shown, are not reliable. Nursery stock for export is, in many cases, grown in the vicinity of hedges and trees infested by brown-tail moths, by the gipsy moth, and by other injurious insects as yet not introduced into the United States, and down to the present time there seem to have been no special precautions taken by the nurserymen to prevent the infestation of their stock by injurious insects. It seems reasonably sure that the infested nursery stock imported last winter into the United States came from such regions as have just been described. In the late June and July flight of the adult brown-tail moths coming from hedges or woods adjoining nursery plantations many of these moths must have laid eggs upon the young nursery stock in the vicinity. These eggs hatched in August, the very small young larvæ fed somewhat upon the leaves, webbed up into their characteristic winter nests, and were sent with the seedlings to America. The nests are noticeable, and only extreme carelessness, indifference, or ignorance on the part of the French exporters could have allowed them to be packed without removal. The French exporters now promise to take all possible precautions, and the French minister of agriculture has promised to found a competent governmental nursery inspection service under the direction of Dr. Paul Marchal, a most learned and competent man, and to thus guarantee the freedom from pests of nursery stock shipped to the United States in the future.

In England, as in France, there is no governmental nursery inspection. Conditions in the nurseries are somewhat better than they are in France, but the brown-tail moth occurs in England, and other very injurious insects which may easily be imported upon nursery stock.

Officials of the government board of agriculture, in London, stated that the Government had had the establishment of an inspection service under consideration, and was perfectly willing to institute such a service, but that the demand must come from the British nurserymen themselves. Therefore, prominent members of the National Horticultural Trades Association of Great Britain and Ireland were interviewed, and the near establishment of a competent inspection service under the board of agriculture seems probable.

INTERSTATE INSPECTION.

During the fiscal year 1909 the file of the state nursery and orchard inspection laws has been made complete by continued correspondence with the state inspectors in charge, and a revised circular has been issued, giving the requirements for shipping nursery stock into the different States, for the benefit of people engaged in this industry. It is necessary to devote considerable attention to this matter, as new laws are being enacted almost every year and new regulations are continually being made by the inspectors or official boards in charge of the work. An effort has been made to secure data concerning the cost of inspecting nurseries in the United States, the amount appropriated to carry on this work, and the work of orchard inspection as well. A statement of the number of orchards annually inspected has been compiled, with the views of the different inspectors concerning the efficiency of the work under state supervision as it is now being conducted. This information should be of considerable value as forming a good basis for a general law bearing on the inspection of importations from foreign countries.

WORK IN BEE CULTURE.

The work in bee culture has been carried on, as before, under the direction of Dr. E. F. Phillips, and covers practically the same projects as in the previous year.

WORK ON BEE DISEASES.

The main line of work carried on this year was, as in former years, an investigation of the brood diseases of the honey bee. The study of the micro-organisms that cause disease or are found in diseased material has been continued. As was stated in the last annual report, the cause of American foul brood was determined in the investigations of this office, and during the year a further study of this organism has been made. The cause of European foul brood is not yet fully established, but a study of one organism (temporarily named "Bacillus Y") now under investigation promises favorable results as soon as more suitable culture media can be obtained for its cultivation. Extensive experiments on the amount of heat and chemical disinfectants necessary to kill the spores of *Bacillus larvæ*, the cause of American foul brood, have been begun during the year. These results are highly important in determining the methods of disinfection to be used in treating an infected apiary.

Work on the distribution of the different brood diseases was taken up on a more extensive scale at the beginning of the season of 1909,

and samples are now being received from all parts of the country. The material for this work was obtained by sending out circulars to correspondents of the office and by advertisements in bee journals. During the past year 280 samples were received and examined, of which 180 were obtained during June. This taxes the capacity of the present bacteriological laboratory. The information gained from this work has already been of great value, especially in giving information to state legislatures which are contemplating the passage of laws providing for the much-needed inspection of apiaries. At the close of the present season all of the available data will be arranged geographically for publication. This is the first extensive attempt at a study of the distribution of bee diseases in this country. Circulars giving symptoms and treatment of the various bee diseases are sent out to all bee keepers whose names can be obtained in regions from which samples are received, and every effort is made to aid the bee keepers in getting the diseases under control. The practical value of this work is perhaps greater than that of any other line of work now being attempted, nor is there any aid more needed. It was found that European foul brood has recently appeared in the San Joaquin Valley in California and in western Mississippi, causing considerable damage. In these cases special circulars were sent out to bee keepers in the regions especially in danger. The work on distribution is showing the presence of disease in many localities previously unreported, and indicates even greater losses from this source than have been recognized in the past.

During the past winter a large paper was almost completed reviewing all the work that has been done on the cause of infectious diseases. This will help greatly in clearing up the confusion still existing in the minds of many bee keepers as to the nature and extent of the work which has been done by the various investigators who have worked on this subject.

The work on new and better methods of treatment which was begun on a large scale during the fiscal year 1907–8 was continued the past fiscal year, as far as the apiary facilities would allow, with very valuable results. This work is being continued during the present season, the object being to get less expensive methods. This work will require considerable time and labor.

During the past year the bee keepers of several States have been active in attempting to get laws enacted providing for inspection of apiaries. Satisfactory laws of this kind were passed in South Dakota, Indiana, and Iowa, and proper regulations were made in Hawaii. The proposed bills failed of passage in Pennsylvania, New Jersey, Massachusetts, Connecticut, and Illinois. The proposed revisions of previously enacted laws in California and Texas also failed. The chief reasons for failure in these cases is that but few bee keepers go before the legislatures and those who do go are not provided with sufficient data as to the distribution of the diseases and losses resulting from them. This office helped in the drafting of several of the proposed bills, and aims to aid in every legitimate manner by furnishing information as to the distribution of diseases and the losses resulting therefrom.

STUDIES OF THE STRUCTURE AND DEVELOPMENT OF THE BEE.

Work on almost all other lines of apicultural investigation has shown the very urgent need of a careful and detailed study of the structure and development of the bee. The knowledge of the average bee keeper concerning the animals with which he works is much less than that of men engaged in almost any other line of animal industry. Without knowledge of this character it is very difficult, if not impossible, to make proper progress in a study of the pathology of bee diseases, queen rearing, behavior and activity of the bee, and many other important lines of investigation. The work done by other investigators has been shown, in the main, to be either very inaccurate or incomplete and, to supply these wants, investigations in these two fields were carried on during the past year. Such work will not only add greatly to our knowledge of the bee, but will unquestionably be of great value in devising and correcting practical manipulations. It can scarcely be expected that the average bee keeper will show much interest in such work, but the practical results of such investigations will prove of great value to investigators and of interest to all progressive bee keepers.

WAX ANALYSIS.

During the past year a beginning was made in collecting samples of beeswax from all parts of the United States for analysis and study. These samples are to be turned over to the Bureau of Chemistry for analysis, and tests will also be made of the bleaching properties and in other ways to determine the relative commercial value of the various waxes. It is hoped to prepare for beeswax a mass of material comparable to what has been done for American honeys, as reported last year. Some work was done on methods of wax extraction.

THE ACTIVITY OF BEES.

The work on the daily activity of a colony, mentioned last year, has been brought to a close, and results will be prepared for publication soon. Some investigations were made as to the methods of gathering propolis and the sources from which it is gathered. This has been a much debated question among bee keepers since Huber's time.

The basis for intelligent practical manipulation rests almost entirely on a knowledge of bee behavior. The literature on this subject is very scattered and there is no single available English publication which can be relied on fully. A general review of this subject with some new observations has been begun during the past year and will be completed as soon as possible.

STUDY OF THE STATUS OF BEE KEEPING.

During the past year a publication (Bul. 75, Part VI) was issued giving a summary of the best available information concerning the present conditions of the bee-keeping industry in the United States. Another publication (Bul. 75, Part V) of the year was a report on bee keeping in Hawaii, this being an account of the trip to Hawaii mentioned in the last annual report. As supplementary to this, a paper was issued by the Hawaii Agricultural Experiment Station

on Hawaiian honeys. The detailed study of bee keeping in Massachusetts, mentioned last year, is completed and the results have been published. (Bul. 75, Part VII.)

Detailed studies of bee-keeping conditions have proved so valuable that similar work is being carried on in Maryland, Pennsylvania, and parts of Virginia. By getting in direct touch with bee keepers it is possible to locate many new outbreaks of disease and to help in various other ways. It is also a great help in getting our publications into the hands of bee keepers. It is hoped to enlarge the scope of this work as rapidly as possible.

UNCLASSIFIED WORK.

Much work has been carried on during the fiscal year which can not be classified under the main topics already considered.

INSECTS INJURIOUS TO THE PECAN.

Investigations of insects injurious to the pecan, made in earlier years and carried on with a fair degree of success by means of special correspondents, and later by the help of a special agent, have been continued. An agent has been stationed in Florida, taking occasional trips into South Carolina. The principal insect under investigation has been the pecan bud moth, which seems to be the most injurious enemy of the pecan tree. Its life history has been under especial study. Similar life-history studies have been made upon another bud moth, upon a leaf miner, and upon certain forms of borers. A preliminary report will soon be put into shape.

INSECTS INJURIOUS TO SHADE TREES AND ORNAMENTAL PLANTS.

There is great demand for information in regard to insects injurious to shade and ornamental trees, and an effort is constantly being made to bring the published information to date. The facilities for extensive experiments, however, are slight. Circulars and Farmers' Bulletins containing information in regard to some of the principal pests, such as the tussock moth, fall webworm, imported elm leaf-beetle, bagworm, green striped maple-worm, red spider, the rose slugs, and the leopard moth, as well as the cottony maple scale, have been published.

A large amount of time is taken up in correspondence on this class of pests each year.

WORK ON SCALE INSECTS.

During the year a large amount of scale-insect material has been received from different parts of the world and carefully studied by experts. It is most important that the Bureau should be thoroughly informed on the scale insects, not only of this country but of all parts of the world, since there is no group of insects so liable of introduction from one country to another as this group. A second supplementary list of recently described scale insects, with full bibliography, has been prepared for publication.

OTHER WORK.

An elaborate attempt has been carried on to systematize all the notes and records of the Bureau and to verify the determinations of practically all specimens referred to in the notes. A large number of biological records have been made of species hitherto unstudied in the Bureau.

Work on the part of specialists in the Bureau, referred to in previous reports, in the determination of specimens sent in by state entomologists and other workers in practical entomology, has increased. A close estimate of the number of specimens named in this way during the fiscal year reaches the very large total of 23,000. The correspondence of the Bureau continues to increase. During the fiscal year, in addition to answers to correspondence by circulars, nearly 19,000 letters have been written.

The publications of the Bureau during the year have reached 23 numbers.

PROPOSED WORK FOR THE FISCAL YEAR 1910.

At the present writing the work for the fiscal year 1910 is well under way and, in part, consists of a continuation of the lines just indicated.

With the gipsy moth and brown-tail moth very slight changes in methods and plans are being considered. Constant effort will be made to reduce the cost of the methods in use, and constant experimentation will be carried on, in the hope of finding some large wholesale manner of caring for woodland regions. Where property is of sufficient value or interest to the owners, the moth is handled without great difficulty, but the large tracts of low-priced woodlands, where the owners can not afford or are unwilling to spend any considerable sums of money, constitute the most serious problem in the course of the work.

It is planned to continue in the same way the importation of useful insects, especially the parasites of the gipsy moth and brown-tail moth, of the imported elm leaf-beetle, and of the codling moth.

With the Mexican cotton boll weevil the most important work is being conducted in Louisiana. Two years' experience in that State have convinced all careful observers that special means of control of the weevil must be devised to suit the peculiar conditions which exist in the Mississippi Valley. The methods that have been successful elsewhere have been tried, and have been found inadequate. The means utilized in Texas resulted from careful technical studies of the life history and habits of the weevil. Logically, therefore, since in the Mississippi Valley the conditions are so different, similar careful technical studies of the life history and habits of the weevil must be made there as the basis for remedial work. For these reasons the Bureau has established a laboratory at Tallulah, La., in a region typical of the Mississippi Delta country. All features of the life history of the weevil are being carefully investigated there, and field experiments with new lines of control have been instituted. This work will occupy the attention of three expert assistants resident in the delta. Especial attention will be paid to the increased effectiveness of parasites. This is the most hopeful aspect of the situation at present, but every possibility will be investigated with

care. As heretofore, the experimental field work, however, will be continued throughout the whole infested area. As far as practicable, the work will be reduced in Texas and increased in Louisiana. In the latter State field work is under way at eight places. Experiments with machinery for the control of the beetle will be continued. The status of the weevil will be determined from time to time, and estimates of damage will be made and field work in the determination of the extent of dispersion will be carried on for the benefit of States that have quarantines in operation, as well as for the information of planters, who must make the earliest possible preparation for the arrival of the pest. Moreover, attention will be paid to the discovery of isolated colonies, and if any should be discovered, energetic attempts will be made to stamp them out.

With regard to tobacco insects life-history studies will be continued, and demonstrations, through cooperative experiments as to the effect of poisons, with fall plowing and other methods, will be carried on.

New projects under the section of southern field crop insect investigations have been entered on during the fiscal year 1910. For many years the insect enemies of sugar cane and rice have levied their regular tax upon two of the more important agricultural industries. In 1902 the entomologist of the Louisiana Experiment Station estimated a loss of $54,000 for the season on one plantation of 3,227 acres of cane. In 1908 it was ascertained from thoroughly reliable sources that the damage by a single insect on one sugar plantation near Brownsville, Tex., amounted to $10,000.

Among the rice insects it is estimated that the root weevil was responsible for an annual loss in Texas alone of $360,000. The fact that the boll weevil is forcing many planters to abandon cotton and put their land in sugar cane and rice gives additional importance to these enemies of these crops. The Bureau has obtained the services of Mr. D. L. Van Dine, formerly of the Hawaiian experiment station, to engage in a special investigation of sugar-cane and rice insects under Mr. W. D. Hunter. On account of the necessity of beginning the work near the middle of the crop season, in 1909, it will be possible to do little more than make a general survey during the remainder of the season. This will be carefully done; the special problems that need attention will be determined, and the best places for experimental work will be selected. This preliminary work will enable the agent in charge to undertake strictly control measures with the crop of 1910.

In connection with the work on sugar-cane insects, an investigation of the Argentine ant has been begun, and will be carried on throughout the year. The ant is a serious pest in houses, in orchards and gardens, and on cane fields—in the latter instance since it protects and cultivates the mealy bug of the sugar cane. During the fiscal year 1910 work on the ant will be restricted to the sugar-cane aspect of its habit. The cooperation of the entomologist of the Louisiana Agricultural Experiment Station has been obtained, and an agent has been stationed in Louisiana to devote his full time to the determination of the exact importance of the ant in its relation to the cultivation of sugar cane and, if possible, to devise practical means of control.

In connection with the investigation of insects affecting southern crops an incidental study will be made of the cotton red spider in South Carolina and adjoining States, and the cotton root-louse, which occurs in the same region. It is the opinion of the state entomologist of North Carolina that the root-louse is perhaps the most important insect enemy of cotton in that State.

The work upon cactus insects will be completed during the year, and work upon the life histories of ticks will be continued.

With forest insects the investigations of the past fiscal year will be continued. With insects affecting deciduous fruits the work in general will be a continuation of the lines already in progress. The pear thrips problem being practically solved, it remains only to carry on large-scale demonstration work, in order to show fruit growers exact methods and results. The work upon cranberry insects, the orange thrips, and codling moth will be continued. The work upon the grape root-worm will be practically discontinued, but work upon the apple maggot will be begun.

With the cereal and forage-crop work there will be no great expansion of the investigations, but work will be begun with a Hemileuca caterpillar damaging stock ranges in New Mexico and upon the alfalfa weevil injuring the alfalfa crop in Utah, as also with the leafhoppers affecting pastures.

PLANS OF WORK RECOMMENDED FOR YEAR ENDING JUNE 30, 1911.

In accordance with the request of the Secretary of Agriculture, no increases in the estimates for the year 1911 over the appropriations for 1910 are made. Some small changes of funds from one investigation to another are recommended. The practical completion of the pear-thrips investigation in California renders it desirable to reduce the sum set aside for the investigation of deciduous fruit insects by $6,000, and to add that amount in part to the investigations of insects affecting forage crops, for the especial investigation of the Hemileuca caterpillar in New Mexico and the alfalfa weevil in Utah, and in part also to the fund for the investigation of forest insects, which needs additional assistance. There are very strong reasons for urging certain increases in promotions, but as the reasons for reducing the expenses of the Government seem even stronger, no recommendations in this direction are made.

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